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(54) PRESERVATION AND IDENTIFICATION OF PARTICLES ANALYZED BY FLOW-THROUGH APPARATUS

(71) We, COULTER ELECTRONICS INCORPORATED, a corporation organised and existing under the laws of the State of Illinois, United States of America, of 590 West 20th Street, Hialeah, Florida, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement:—

This invention relates to an apparatus for identifying and preserving particles and correlating them with their measured characteristics.

Many people have concerned themselves with the study of particle characteristics and especially the study of physiological cells. There are two schools of thought as to how best to study these cells.

Probably the earliest school taught flowing the cells one at a time through some type of sensing zone where a characteristic such as for example size or color is measured. This measurement may be counted and hence the cells themselves are counted. This technique is referred to as a "flow through" technique.

In all such apparatuses, the particles have their characteristics measured in gross, albeit individually, and as soon as the particles have passed the sensing zone where the measurements are actually made, the particles are discarded or comingled with others thereby losing their individual identities. In effect, the characteristics are measured and correlated statistically to a given sample, then the particles are discarded, thus precluding individual identification of the particles by trained observers. For the most part, both for industrial and medical applications, the data thus obtained can be somewhat satisfactory even though only gross sample can be preserved

and further tested, and even though any particular data cannot be related to any single particle.

The second school taught the mechanical duplication of the function performed by a human observer such as a trained cytologist, and is referred to as "Pattern Recognition". In this procedure a sample such as blood is smeared on a slide or substrate. A microscope locates the individual cells on the slide and their images are scanned, for example by television techniques. The two dimensional cell information, along with color, color density and the possibly fluorescence of the cell at many locations thereon are measured and stored in a computer memory. Algorithms are used for manipulating the stored data in an attempt to identify the cell.

Both techniques have been quite successful but not perfect. The former technique is fast but only measures the gross parameters. The latter technique is quite slow but provides rather thorough cell identification, although improvement is still possible. The information gleaned using the flow through technique may not be obtained when utilizing the pattern recognition technique and that information may be necessary for a complete positive cell identification.

An apparatus for automatic examination and separation of cells is described in British Patent Specification 1,485,284 (not published at the date of the present application). In the apparatus described in specification 1,485,284, particles in suspension move through the sensing zone of a particle detector, then through a particle separator where the suspension is broken into discrete droplets containing the particles, then passed to a substrate. The information derived from the sensing of each particle is stored in a memory along with the time in-

tervals between the sensed particles. The substrate is moved at a constant speed in a particular pattern so that the droplets and particles reach the substrate having a particular spatial pattern which is related to the time interval between sensed particles. This information is retained so that the particle characteristics and location on the substrate can be correlated. While the apparatus described is effective, the speed of the substrate must be accurately maintained in order to maintain a correct correlation between the time intervals of sensed particles and the spatial pattern formed on the substrate. Furthermore, the retention of the time information between particle sensings and the correlation with the spatial pattern on the substrate requires additional space in the computer memory and it is desirable to reduce the size of the computer memory and possibly eliminate the computer in order to reduce costs. As described, all the particles are retained on the substrate, even those which may be of no interest, thus requiring large substrates whose surface areas are largely covered with particles of no interest.

The present invention provides an apparatus for identifying particles in a liquid suspension, the apparatus comprising: a particle scanning device including, means for containing a quantity of suspension carrying particles, a sensing zone for producing at least one characteristic signal representing at least one physical characteristic of each particle passing therethrough, means for moving the suspension in a stream through the sensing zone and out of the particle scanning device such that particles separately pass therethrough and out, a substrate; sequencer means coupled to said scanning device and said substrate and operative in response to at least one particular characteristic signal for each particle to develop a particular sequence signal and to direct the stream and particle therein producing said characteristic signal to a particular location on said substrate corresponding to said particular sequence signal and; memory means coupled to said scanning device and said sequencer means and operative in response to said at least one particular characteristic signal to store said characteristic signal and said particular sequence signal or other signal identifying the particular substrate location, whereby each particle location and characteristic can be correlated.

The preferred embodiments will now be described by way of example, with reference to the drawings accompanying this specification of which:

Figure 1 is a combined diagrammatic and block diagram representation of an apparatus embodying this invention; and

Figure 2 is a block diagram representation of an electronic circuit for use in the apparatus of Figure 1.

The basic components of the apparatus shown in Figure 1 are first means to make measurements of a gross nature on particles carried in suspension as these particles are passed in succession through a sensing zone while deriving in addition a count sequence of particles of interest and storing them at memory locations specified by the count in the sequence; second, means for projecting the particles after passing through the sensing zone in a stream against a substrate that moves relative to the stream in accordance with a predetermined plan based on that count sequence such that successive particles of interest are deposited at predetermined locations on the substrate, which locations are correlatable to the specified memory locations.

In the use of the apparatus shown in Figure 1, the measurements from the scanning of the particles by the sensing zone and the particle count or location information are stored and made available for further measurements on the particles carried by the substrate either immediately or for future reference. Either by manual means or by automatic apparatus, the individual particle characteristics and particles on the substrate can be correlated with the results of further inspection and analysis of each particle. In this way, substantially more can be determined about any particular particle than could be derived from either the gross measurements produced by the sensing zone or microscopic examination (automatic or visual) alone.

Referring now to Figure 1 in more detail, the apparatus is generally designated by the reference number 10 and the mechanical and fluid components for the most part are shown mounted onto a base or platform 12. A particle scanning device 14 is shown mounted on an arm 15 of a standard 16. Standard 16 is rotatable in the directions indicated by the arcuate arrow and carries a microscope 17 on an arm 19 of standard 16. Particle scanning device 14 at least includes a sensing zone and a droplet generator of the type described in specification 1,485,284. The droplet generator is arranged so that the droplets are ejected towards a substrate 18.

A substrate 18 is positioned downstream of scanning device 14. Substrate 18 has a surface that will retain any particles contained in droplets impinging thereon and will prevent their movement from their receiving location so that their positions remain substantially fixed upon impact. For example, the substrate may have a special surface of frosted or fritted glass or it may be made from absorbent material such as

filter paper or porous rigid resins in order to enable the liquid of the droplets to be drawn away by suction and/or capillary action. Substrate 18 is mounted on a precision scanning stage 20.

The precision scanning stage 20 operates in response to indexing signals to move a predetermined amount in the X and Y directions indicated by arrows 24 and 26. The specific amount and directions moved in response to each indexing signal are preprogrammed by means built into the scanning stage. For example, the scanning stage may start from a first Y position and then twenty discrete steps in the Y direction indicated by arrow 26, then on the twenty first indexing signal it will move one step in the X direction indicated by arrows 24. The scanning stage may then return to the first Y position displaced one step in the X direction and repeat the steps through the Y positions. The stepping then defines a number of rectangularly spaced locations on the face of substrate 18, the boundaries of which are identified by lines in the Figure. Any particle may thus be located later by its X and Y coordinates. At the end of a predetermined number of indexing signals, representing a predetermined number of steps, for example, 1000, of scanning stage 20, it is programmed to stop, or return to an initial or starting position. If the stage is programmed to stop in the last position a separate reset signal must be provided in order to return the stage to the starting position. Each indexing signal supplied to scanning stage 20 can be a pulse which causes it to step or index one position to the following location in the sequence, or it can be a specific address identifier, preferably in digital form, which causes the table to sequence to a specific or predetermined location.

Referring again to particle scanning device 14, the droplet generator therein includes a jet forming orifice (not shown) located at the bottom of device 14. A stream 28 is ejected from the jet forming orifice in a manner which causes droplets to be formed at a predetermined distance below the orifice. The stream 28 enters a droplet charging ring 30 and passes as droplets through deflection plates 32.

Particles to be studied are suspended in an electrically conductive solution and introduced into the particle scanning device 14. In scanning device 14, the particles in suspension move one at a time through the sensing zone noted, causing the effective electrical impedance of the aperture to change in accordance with the volume of the particle. This changed impedance is sensed and employed to generate a signal whose amplitude is proportional to the size or volume of the particle passing through the aperture. The number of signals, their order or arrival and individual amplitudes can be stored for more detailed particle analysis.

Other information relating to particles can be obtained by transducing means responding to the passage of particles through electrical or optical sensing zones in liquid suspension. For example, the so-called gross physical characteristics of the particles can be measured and recorded as electrical analog quantities and these physical characteristics may include response to aperture currents of multiple frequencies, response to different wavelengths of light, fluorescence, electrical opacity and so on.

Electronic circuitry for operating particle scanning device 14 and for receiving particle information therefrom; for operating charging ring 30, deflection plates 32 and scanning stage 20 is shown connected to the aforementioned items and identified by the reference number 34. The electronic circuitry 34 is connected to a computer 36 or some other information storage device for storing the particle information and certain other information to be described hereafter.

In operation, the particle information, in the form of signals developed in particle scanning device 14, is coupled to electronic circuitry 34. The particle producing the received electronic signals exists in stream 28 by way of the jet forming orifice and is included in a droplet at charging ring 30. Each droplet contains no more than one particle and the time after receipt of the particle identifying information by electronic circuitry 34 at which the droplet containing the particle is formed can be identified. The droplet containing a particle will be directed to and impinge on substrate 18 at a particular location at this later time, only if the information received by the electronic circuitry 34 meets particular requirements, such as exceeding a particular threshold, and if the apparatus has stabilized by passage of a sufficient period of time after initialization or after recognition and direction of the last particle containing droplet. If any of the above conditions are not met, electronic circuit 34 applies a charging voltage to charging plate 30, and causes the droplets to be charged to a particular voltage. The charged droplets then pass through deflection plates 32 where they are deflected at a particular angle to a waste receptacle where they may be discarded or saved for later, further useage.

The signals received by electronics circuit 34 for that particle also cause a particular count signal to be developed. The count signal is coupled to the scanning

stage 20 causing the stage to index to the next position in the indexing sequence so that the next droplet directed to substrate 18 impinges at the next location in the sequence. The count signal developed in electronic circuit 34 and the results of the measurements made on each particle, i.e., the particle signals developed by scanning device 14, are both coupled by electronic circuitry 34 to computer 36 so that the particle characteristics and the particle location on substrate 18 can be correlated.

At the end of a full operating sequence, when all of the locations on substrate 18 are filled or when the sample is entirely exhausted and the particles have been properly prepared, as for instance by staining and fixing microscope 17 can be rotated into position over substrate 18 for automatic particle inspection. The electronic circuitry 34 can then be activated to sequence scanning stage 20 to each location so that a pattern recognition scan can be performed as described in the specification 1,485,284, with the information so obtained and the information in the memory being collected for accurate particle identification as described in that specification.

Referring now to Figure 2, a more detailed block diagram of the apparatus is shown including a more detailed showing of the elements comprising electronic circuitry 34. Specifically, Figure 2 shows a simple single parameter single-threshold embodiment. Particles to be studied such as blood cells are diluted in a fluid suspension and the fluid suspension is placed in a sample reservoir 40 which is part of the particle scanning device 14. It is assumed that air pressure and other necessary peripheral needs are met. When device 14 is actuated the particles in suspension flow from reservoir 40 and to through one or more particle sensing zones and a jet forming orifice shown all represented in Figure 2 by number 42. For purposes of this explanation, we shall assume for simplicity that it is desired to measure and record the volumes of all particles greater than a predetermined minimum and preserve these particles for further examination. In the apparatus 42, particle pulses having amplitudes proportional to the particle volume will be developed in response to passage of each particle through the sensing zone. The particles in suspension exit device 14 through a jet forming orifice in the form of a stream which breaks into droplets. This breakup occurs at charging plate 30. Because of the sample dilution chosen, a great many droplets are produced which contain no particles between droplets containing a particle. Also, the dilution ratio and droplet size are chosen such that a droplet will contain not more than one par-

ticle. Only certain ones of the particle containing droplets will be of interest.

The particle pulses developed by the passage of the particles through the sensing zone are amplified by amplifier 43 and coupled by way of conductor 44 to theshold circuit 46 and analog gate 48. Threshold circuit 46 is of the well known type which will develop a threshold pulse as soon as the signal received at its input exceeds a predetermined amplitude and will maintain this threshold pulse until the input signal drops below the predetermined amplitude. We will assume for this example that the particle pulse developed exceeds the threshold level of threshold circuit 46 so that a threshold signal is developed consisting of a binary high state signal or a logical one at path 47. This description assumes a positive logic, i.e., a logical "one" is represented by a positive voltage or high state signal. Other logic is of course useable if compatible. This threshold signal is coupled to one input 52 of an AND gate 54.

The electronics circuitry 34 shown in Figure 2 is initiated by presenting a start signal in the form of a high state binary signal at start input 62. This signal may be initiated in a number of ways such as, for example, by the use of a start switch and power source, it being understood that all portions of the apparatus including the droplet formation device and sensing zone are operating properly and that droplets are being directed to the waste receptacle. The high state signal is coupled from start input 62 to the reset input 64 of a counter 58 and to one input 66 of an OR gate 68.

The high state signal coupled to counter 58 will cause counter 58 to reset to zero count. Counter 58 counts from zero count to a predetermined number such as 1,000 and develops a different count signal for each count. This count signal is utilized to correlate the particle characteristics and the substrate location. Each count includes a number of signals, preferably digital, which are coupled to a memory 60 for addressing a particular memory location. When the count in counter 58 reaches the prescribed number, it develops a high state signal at conductor 70 which is coupled via inverter input 72 to AND gate 54 presenting a low state signal to AND gate 54. Until this count is reached, a low state signal appears at conductor 70 so that the input at AND gate 54 before the desired total count is reached is a high state signal.

The start signal coupled from start input 62 to input 66 of OR gate 68 causes OR gate 68 to develop a high state signal which is coupled to the set input 74 of a bistable multivibrator 76, more commonly known as a flip-flop. Flip-flop 76 changes states

in response to the signal at input 74 and develops a high state signal which is coupled to input 78 of AND gate 54.

The high state signal appearing at input 78 of AND gate 54 and the low state signal appearing at the inverter input 74 of AND gate 54 appear almost instantaneously after receipt of the high state start signal and remain at these inputs so that upon receipt of the noted threshold signal at input 52 AND gate 54 changes states and develops a high state AND gate signal at its output which is coupled to delay circuit 80, trailing edge detector (T.E.D.) 81, the count input of counter 58 and control input 50 of analog gate 48.

The AND gate signal coupled to the control input 50 of analog gate 48 causes the analog gate to open and pass the part of the particle pulse which exceeds the threshold level fixed by threshold circuit 46 on conductor 55 to the analog-to-digital converter, (A/D converter) and memory 60, thus allowing receipt of these pulses only after the apparatus is initialized and synchronized with the pulses and droplet information. Any additional particle related characteristics developed by the other forms of sensing zones which may be employed at 42 in device 14 also are coupled by way of conductor 44, or other conductors not shown, through analog gates such as gate 48 (not shown) to A/D converter and memory 60 when opened by receipt of a gate signal at their gate inputs. The A/D converter and memory 60 converts the analog signals received from analog gate 48 and any other such gates to their digitally equivalent signals and stores these signals at the address designated by the count signal developed by counter 58.

The AND gate signal coupled to counter 58 is counted causing counter 58 to develop a count signal as previously discussed. This counting signal is passed to A/D converter and memory 60 for addressing the memory location where the particle characteristics are stored.

Trailing edge detector 81 operates in response to the trailing edge of the AND gate signal to develop a delayed trigger pulse which is coupled to a monostable multivibrator 82, more commonly known as a one shot. One shot 82 develops a high state signal of fixed amplitude and duration in response to the delayed trigger pulse which is coupled to T.E.D. 84. T.E.D. 84 operates in response to the termination of the high state signal from one shot 82 to develop a further delayed trigger pulse which is coupled to one shots 86 and 88 in order to provide a desired total delay period.

One shot 86 develops a shorting pulse that is coupled to a shorting device 87 which consists of a field effect transistor (F.E.T.)

89. The shorting pulses causes F.E.T. 89 to conduct and provide a low impedance path to ground potential. This low impedance path shorts out or reduces to a low value, the voltage normally coupled from voltage source 90 through resistor 91 to charging plate 30. The delay provided by the circuitry, T.E.D.'s 81 and 84 and one shot 82 causes the charge to be removed from the charging plate 30 at the time that the particle which produced the threshold pulse passes through charging plate 30 and a droplet is formed surrounding the particle so that the droplet containing the noted particle is not charged, and will then drop to substrate 18 at the particular location on substrate 18 corresponding to the count number noted previously. All other droplets will be charged by charging plate 30 and, when they pass through deflection plates 32 will be deflected to waste receptacle 21.

The AND gate signal developed at AND gate 54 is also coupled to delay circuit 80. Delay circuit 80 after a period of time sufficient to allow operation of T.E.D. 81 develops a high state signal at its output which is coupled to input 90, the reset input of flip-flop 76, causing flip-flop 76 to reset and terminate the high state signal coupled to input 78 and AND gate 54. Termination of the high state signal coupled to input 78 and AND gate 54 acts to inhibit AND gate 54 thus preventing operation of this circuitry and making it impossible for any subsequent particles to be directed to the substrate until such time as flip-flop 76 is again set. This occurs when the apparatus completes an operation cycle and stabilizes.

As noted previously, the pulse developed by trailing edge detector 84 also is coupled to a one shot 88. One shot 88 changes states in response to receipt of the pulse and develops a high or one state signal at its output for a predetermined time period. This predetermined time period is greater than the time period required for a droplet to move from the charging plate 30 to the substrate 18. The one shot 86 develops a charging pulse at its output of short duration, just sufficient to ensure that only the desired droplets passed unchanged. The high state signal developed by one shot 88 is coupled to a T.E.D. 92 which operates in response to the termination of the high state signal to develop a trailing edge pulse that is used to trigger a one shot 94. One shot 94 changes states in response to the received pulse and develops a high state indexing signal which is coupled to the previously mentioned programmed indexing mechanism 96, preferably a pair of programmed stepping motors, in scanning stage 20 causing the stage to index to the next position in the indexing sequence. Sub-

strate 18 now is positioned for receipt of
the next detected particle containing drop-
let.

A T.E.D. 97 also receives the high state
signal developed by one shot 94, and de-
velops a delayed trigger pulse in response to
the trailing edge of the high state signal.
The trigger pulse is coupled to a one shot
98 which develops a high state signal of
fixed amplitude and duration. The high
state signal developed by one shot 98 is
coupled to a T.E.D. 100 which operates in
response to the termination of this high
state signal to develop a pulse that is
coupled to another one shot 102. One shot
102 operates in response to the pulse re-
ceived from T.E.D. 100 to develop a high
state signal for a short period of time. This
high state signal is coupled to the second
input 104 of OR gate 68 causing OR gate
68 to develop a high state signal at its out-
put that is coupled to the set input 74 of
flip-flop 76.

The events described with respect to the
operation of T.E.D.'s 97 and 100, one shots
98 and 102 and OR gate 68 take up a suffi-
cient period of time to allow stabilization
of indexing mechanism 96 and substrate 18
in their new location and to allow all vibra-
tions to stop, and the stabilization of the
remaining circuits in electronic circuitry
34, such as, for example, the termination
of all operating transients. Flip-flop 76 re-
sponds to the high state signal received at
set input 74 to change states and again de-
velop a high state signal which is coupled
to input 78 of AND gate 54. With the
high state signal present at input 78, and
so long as the full count has not been
reached by counter 58, AND gate 54
operates in response to receipt of the next
threshold signal received at input 52 to
count the signal, store the count and par-
ticle characteristics in memory 60, direct
the droplet entrapping the particle to the
appropriate location on substrate 18, and
then index scanning stage 20 and substrate
18 to its next location.

When an appropriate number of par-
ticles have been counted by counter 58 it
develops a high state signal at its output
which is coupled to an indicator 71. In-
dicator 71 provides an output for notifying
personnel that the sample is to be changed
and that it is necessary to initiate scanning
and/or microscopic review.

The high state signal from counter 58 is
also to input 72 of AND gate 54. The high
state signal inhibits AND gate 54 prevent-
ing it from developing a high state signal
at its output in response to receipt of any
further threshold signals at input 52 and
thus terminating operation of the electronic
circuitry 34. At this time all of the pro-
grammed locations on substrate 18 have

been filled with particles which have been
selected and the particle characteristics and
count number in the counting sequence
have been stored in the memory. The in-
formation in the memory can be obtained
by use of readout devices, commonly em-
ployed with such memories such as for
example cathode ray tubes or printers.
With the particle characteristics and count
of the sequence known and with the sub-
strate location corresponding to that count
also known the particle characteristics and
particle location can be correlated either
manually or by appropriate indexing
machines so that the individual particles
may be further studied. Microscope 17
may be moved into position over substrate
18 and scanning stage 20 so that particles
may be visually observed as the stage is
indexed to each new location and the par-
ticle characteristics are displayed by the
selected readout device.

Although a single embodiment has been
shown and described with respect to
Figures 1 and 2, it is to be understood that
modifications and variations are within the
scope of this invention as defined by the
appended claims. For example, Figure 2
shows the use of a single threshold cir-
cuit 46 in response to particle pulses that
exceed a predetermined threshold. A win-
dow threshold circuit could be employed in
place of threshold circuit 46 which would
operate to develop a threshold signal only
in response to pulses having an amplitude
greater than a first predetermined amplitude
and less than a second predetermined amp-
litude. Threshold circuit 46 can also oper-
ate in response to characteristic signals
other than particle pulse signals produced
by passage through a Coulter type aperture,
for example, signals from an optical density
or fluorescence detector, or a characteristic
signal which is the combination of two or
more of these signals. Substrate 18 need
not be a rectangular plate but can be an
elongate tape such as was described in
specification 1,485,284. When an elongate
tape is used, it can index in one direction
only as, for example, in the direction in-
dicated by arrow 26 in Figure 1, thus
moving the tape in a continuous path from
a starting point of the tape to the end
point. It is also possible to deflect droplets
containing particles side by side to separate
locations on the tape if the tape is of suffi-
cient width, then index forward in the same
manner as with substrate 18 and deposit
droplet containing particles at the next
locations in the sequence. It is possible to
deflect the droplets differently for certain
counts in the sequence so that the table is
maintained stationary and not moved in the
direction indicated by arrow 26.

In an alternative embodiment scanning

stage 20 can be connected directly to computer 36 as shown by the dashed line in Figure 1. The XY location for the scanning stage is fed to the computer 36 and provides the address for the particle information for the particle at that location. In this embodiment counter 58 in Figure 2 acts only to count to the total desired number and need not be connected to memory 60.

In summary, there has been disclosed a simple system which recognizes and detects the particle characteristics and then places the particles on a substrate in a specific pattern and correlates this pattern with the characteristics, without the need for determining the time relationships between particle occurrences. A further feature of the system is that only particles sensed by the sensing zone are preserved for further examination, thus reducing wasted substrate. The system allows rapid initial screening of particles such as cells, with retention of the cells of interest for later detailed analysis.

WHAT WE CLAIM IS:—

1. An apparatus for identifying particles in a liquid suspension, the apparatus comprising:

a particle scanning device including, means for containing a quantity of suspension carrying particles, a sensing zone for producing at least one characteristic signal representing at least one physical characteristic of each particle passing therethrough, means for moving the suspension in a stream through the sensing zone and out of the particle scanning device such that particles separately pass therethrough and out,

a particle scanning device;

sequencer means coupled to said scanning device and said substrate and operative in response to at least one particular characteristic signal for each particle to develop a particular sequence signal and to direct the stream and particle therein producing said characteristic signal to a particular location on said substrate corresponding to said particular sequence signal and;

memory means coupled to said scanning device and said sequencer means and operative in response to said at least one particular characteristic signal to store said characteristic signal and said particular sequence signal or other signal identifying the particular substrate location, whereby each particle location and characteristic can be correlated.

2. Apparatus as claimed in claim 1 wherein said sequencer means include, indexing means for moving said substrate in a predetermined sequence determining a number of particular locations, said indexing

means operative in response to each sequence signal to move to one of said particular locations.

3. Apparatus as claimed in claim 1 or 2 wherein said sequencer means include: threshold means coupled to said sensing means and operative in response to said at least one particular characteristic signal exceeding a threshold to develop a threshold signal;

counter means coupled to said threshold means and operative to count each threshold signal and develop count signals for said count;

direction means coupled to said threshold means and operative in respose to said threshold signal to direct the stream and particle therein producing said threshold signal to said substrate; and

indexing means coupled to said substrate and operative in response to the count signal for each count to move a step in a predetermined sequence whereby the substrate is moved in said sequence and said particle is deflected to a particular location on said substrate.

4. Apparatus as claimed in claim 3 wherein said counter means is a digital counter operative to count each threshold signal and develop a digital count signal for representing each accumulated count.

5. Apparatus as claimed in claim 3 or 4 wherein said memory means include converter means coupled to said scanning device for converting said characteristic signal to a digital number, a memory, gate means operative in response to said threshold signal to enter said digital number into said memory and to enter said count signal into said memory.

6. Apparatus as claimed in any of claims 3, 4 or 5 wherein said sequencer means further include start means coupled to said counter means and said indexing means and operative upon actuation to develop a start signal, said counter means operative in response to said start signal to reset to an initial count, and indexing means operative to return to an initial location.

7. Apparatus as claimed in claim 6 wherein said start means is further coupled to said direction means, said direction means being operative upon receipt of said start signal to allow direction of said stream to said substrate in response to said threshold signal.

8. Apparatus as claim in any claims 3 through 7 wherein said direction means include charging means positioned adjacent said means for moving the suspension for charging said stream, said charging means operative in response to said threshold signal to remove the charge from the stream passing from said moving means and from the particle therein which produced said

threshold signal, and deflection plates having a particular charge thereon positioned adjacent said stream after said charging means in the direction of stream flow for deflecting said charged stream, said uncharged droplet and particle therein passing without deflection to said substrate.

9. Apparatus as claimed in claim 8 wherein said means for moving the suspension include, droplet formation means for forming said suspension into a stream of droplets substantially each particle being contained in a single droplet, said stream of droplets passing through said charging means and deflection plates whereby said droplets containing no particles of interest are charged and deflected and particles of interest are uncharged and pass to said substrate.

10. Apparatus as claimed in claim 8 or 9 wherein said direction means include gate means coupled to said threshold means and counter means and operative in response to said threshold signal and a particular count signal to develop a gate signal and delay means coupled to said gate means and to said charging means and operative a predetermined time after said gate signal to develop a first delay signal, said charging means operative in response to said first delay signal to inhibit charging the droplet and particle therein which produced such signal whereby said droplet and particle are passed to said substrate.

11. Apparatus as claimed in claim 10 wherein said direction means include, second delay means coupled to said indexing means and operative at a predetermined time after said gate signal to develop a second delay signal, said indexing means operative in response to said second delay signal to index the next step in said sequence.

12. Apparatus as claimed in claim 10 or 11 wherein said direction means include third and fourth delay means coupled to said start means, said third delay means operative a third predetermined time after said gate signal to develop a third delay signal, said start means operative in response to said third delay signal to terminate said start signal, said fourth delay means being operative a fourth predetermined time, greater than said third predetermined time, after said gate signal to develop a fourth delay signal, said start means operative in response to said fourth delay signal to develop said start signal.

13. Apparatus as claimed in claim 10, 11 or 12 wherein said start means include actuation means operative upon actuation to develop an actuation signal, second gate means coupled to said actuation means and said fourth delay means and operative in response to said one of said actuation signal and said fourth delay signal to develop a second gate signal, switch means coupled to said second gate means, said third delay means and said gate means and operative in response to said second gate signal to develop said start signal and operative in response to said third delay signal to terminate said start signal.

14. Apparatus as claimed in any of claims 1 to 13 further including visual inspection means for visually observing said particles at said particular location, said sequencer means being operative to sequence to each particular location on said substrate for allowing said visual observation.

15. Apparatus as claimed in claim 14 wherein said visual observation means is a microscope.

16. Apparatus as claimed in any of claims 1 to 15 further including automatic inspection means for automatically inspecting said particles at said particular locations, said sequencer means being operative to sequence to each particular location on said substrate for allowing said automatic inspection.

17. Apparatus as claimed in claim 16 wherein said automatic inspection means is arranged to perform a pattern recognition scan at each of said particular locations.

18. An apparatus for identifying particles in a liquid suspension, the apparatus being substantially as herein described with reference to and as illustrated by Figure 1 of the accompanying drawings.

19. Apparatus as claimed in claim 18 substantially as herein described with reference to and as illustrated by Figure 2 of the accompanying drawings.

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FIG.1.

FIG. 2.